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Use of CONCRETE ON THE FARM

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USE OF CONCRETE ON THE FARM

By Norman C. Teter, agricultural engineer, Agricultural Engineering Research Division, Agricultural Research Service

Concrete is a strong, economical building material that can be cast into practically any shape. Well-built concrete structures last indefinitely and require a minimum of maintenance.

MATERIALS TO IMPROVE CONCRETE

Concrete has high compressive strength, weather resistance, and fire resistance. Its chief disadvantages are low tensile strength, high heat transmission, and water vapor permeability. These may be offset, respectively, by proper use of steel reinforcement, insulation, and vapor barrier material.

Steel Reinforcement

Steel reinforcement increases the tensile strength of concrete—its strength against pulling and bending forces and the effects of temperature and moisture changes. The steel is placed in the forms and the concrete is cast around it.

Reinforcing steel consists of round bars and wire mesh. Table 1 gives data on standard reinforcing bars, which are designated by numbers. Steel mesh, which is used to reinforce concrete slabs, is sold in rolls and mats.

Reinforcement of common farm structures, such as feed and water troughs, is discussed later in this bulletin. More difficult reinforcement work should be designed by an engineer.

Scrap iron that may be available around the farm is sometimes used to reinforce concrete. It must be free of scaling, rust, oil, grease, and dirt.

Insulation

If concrete is used where heat transmission (the loss or gain of heat) is an important factor, walls, floors, or ceilings should be insulated. Insulation may be provided in different ways with concrete.

An insulating core may be installed between concrete faces to form a "sandwich" panel. (If the two concrete faces are reinforced with steel and connected with steel or reinforced-concrete shear pins,

TABLE 1.—*Size, area, and weight of standard steel reinforcing bars*

Bar number	Diameter	Area	Approximate weight of 100 feet
	Inches	*Square inches*	*Pounds*
2	¼	0.05	17
3	⅜	0.11	38
4	½	0.20	67
5	⅝	0.31	104
6	¾	0.44	150
7	⅞	0.60	204
8	1	0.79	267

the panel will have built-in strength comparable to that of an I-beam.) Building sidewalls may be "sandwich" panels made of two concrete faces with 1½ to 2 inches of a semirigid insulating material between them. Such construction provides a relatively inexpensive wall that is about as resistant to heat flow as an insulated frame stud wall.

When concrete does not have to be dense to resist the flow of water, or hard to resist wear and weathering, a lightweight type of insulating material, such as sawdust, corn cobs, or expanded mica, can be used as aggregate. Such material provides insulation and lightens the weight of the concrete. However, it also greatly reduces the compressive strength and weather resistance of the concrete.

When a house is built upon a concrete slab, insulation should be provided between the slab and the foundation wall to prevent the flow of heat from the perimeter of the slab.

When the concrete slab in a house does not have heat in the floor (hot air ducts around the perimeter or radiant heating water or electrical heat in the floor), the subgrade beneath the slab should be insulated. Insulation will keep the inner surface temperature of the slab more nearly equal to the room temperature; this will make the floor more comfortable and reduce the likelihood of condensation. (Insulation of the subgrade may reduce heat loss enough to justify insulating the subgrade of heated floors.) Subgrades of gravel or structural tile provide some insulation, but not nearly as much as even a 1-inch layer of some semirigid insulating material. Semirigid insulating materials include expanded polystyrene, foamed glass, and asphalt-impregnated insulation board.

Insulation can also be used to prevent condensation. Condensation on the north walls of concrete masonry houses, beneath rugs on floors of slab-on-grade construction, and on basement walls can cause problems with mildew, foul odors, and mustiness. NOTE: Condensation should not be confused with the passage of moisture through concrete. Concrete can be made watertight, but condensation can still be a problem.

Vapor Barrier

The passage of water vapor through concrete floors may be prevented by placing a layer of polyethylene, 4 to 6 mils thick, under the slab. Protect the polyethylene when installing it and when placing the concrete because a puncture will ruin the vapor barrier at that point.

The passage of water vapor through walls consisting of "sandwich-type" tilt-up concrete panels may be prevented by using expanded polystyrene as the insulating core. It is both an insulating and a vapor-barrier material.

READY-MIXED CONCRETE

Ready-mixed concrete—concrete ordered from and delivered by a concrete plant—is usually better than job-mixed concrete (see cover photo).

In ordering ready-mixed concrete, you need to specify two things that determine the quality of the concrete:

1. The number of bags of cement to be used per cubic yard of concrete.

2. The number of gallons of water to be used per bag of cement.

The quality of concrete needed depends on the specific job. Use table 2 as a guide in ordering the concrete.

Ready-mixed concrete is sold by the cubic yard. Your dealer can help you estimate the amount needed. Order 5 to 10 percent extra to allow for waste or slight miscalculation in the amount needed.

Air-entrained concrete should be ordered for work that will be exposed to freezing and thawing.

Be ready to place the concrete when it is delivered. For best results, place the concrete in one continuous operation. Delays can reduce the quality of the job .

CAUTION: Never add water to ready-mixed concrete, because it will reduce the strength, durability, and watertightness of the concrete.

The following section, "Job-Mixed Concrete," gives instructions on building forms and on placing, curing, and finishing concrete. These instructions also apply when using ready-mixed concrete.

TABLE 2.—*Guide for ordering ready-mixed concrete*

[Order medium-consistency concrete (3-inch slump)]

Job	Specifications	
	Minimum number of bags of cement per cubic yard concrete	Maximum number of gallons of water per bag of cement
Flat work		
Severe exposure (garbage-feeding floors, floors in dairy plants)	7	5
Normal exposure (paved barnyards, floors for farm buildings, sidewalks)	6	6
Mild exposure (building footings, improvements in mild climates)	5	7
Formed work		
Severe exposure (mangers for silage feeding, manure pits)	7¾	5
Normal exposure (reinforced walls, beams, tanks, foundations)	6½	6
Mild exposure (improvements in mild climates)	5½	7

JOB-MIXED CONCRETE

Materials

Concrete is made by mixing portland cement, fine aggregate (sand), coarse aggregate (gravel, crushed stone, or other), and water. Admixtures are sometimes added for various purposes, one of which is to improve workability.

Portland Cement

Five types of portland cement are available, although some may have to be specially ordered from a local distributor:

Normal (*Type I*) is a general-purpose cement and usually the only type needed for farm concrete work. It is available as regular, air-entrained, and white.

Modified (*Type II*) generates heat less rapidly during curing than Type I and is more resistant to sulfate attack. It may be used where added precaution against sulfate attack is important—for example, in drainage structures where sulfate concentrations in ground waters are higher than normal but not unusually severe.

High-early strength (*Type III*) may be used when it is important to obtain strength shortly after casting concrete—in 1 to 3 days.

Low-heat (*Type IV*) is designed to reduce the amount and rate of heat generated in curing large masses of concrete (large dams, etc.). It has no practical use in farm concrete work.

Sulfate - resistant (*Type V*) should be used when the concrete will be exposed to soils or waters of high alkali content.

Air-entrained concrete should be used for pavements, feeding floors, and other work that will be subject to freezing and thawing. Portland cement is available with an air-entraining agent already added.

Portland cement is sold in paper bags containing 94 pounds of cement, or 1 cubic foot. The cement must be stored in a dry place until used. If it becomes damp, it may set in the bag. Never use cement that has set in the bag—discard it.

Stored cement may become lumpy. If the lumps can be readily pulverized between the thumb and forefinger, the cement can be used; if not, it should be discarded.

Fine Aggregate (Sand)

Fine aggregate, or sand, consists of all grains, small pebbles, or particles of crushed stone that will pass through a ¼-inch-mesh wire screen.

The sand should be clean, hard, and well graded. "Well graded" means ranging in size from fine (excluding dust) to coarse (fig. 1). Well-graded aggregate makes stronger concrete than aggregate that is nearly uniform in size. More cement is required when the sand is fine.

Sand from salt-water beaches requires thorough washing to remove salt and other impurities. It is usually more economical to use sand from other sources.

Air-Entrained Concrete

Air-entrained concrete is more durable and weather resistant than regular concrete. It should be used for all concrete work that will be subject to freezing and thawing. Five to 7 percent of entrained air by volume is desirable in concrete.

Air-entrained, ready-mixed concrete may be ordered. Or, if you do your own mixing, you can use air-entraining portland cement or add an air-entraining admixture to the concrete.

The sand should be free from harmful amounts of vegetable matter, loam, or clay. It may be tested for excessive silt or clay content as follows:

1. Put 2 inches of the sand in a quart fruit jar. Add water until the jar is three-quarters full. Screw on the cover, and shake the jar vigorously until the sand is thoroughly washed. Let the contents settle. The silt will be deposited in a layer above the sand.

2. Measure the layer of silt after the contents have settled for 24 hours. If it is more than one-eighth of a inch thick, the sand is not clean enough for concrete unless the silt is removed by washing.

The sand may be tested for harmful amounts of organic matter as follows:

1. Dissolve a heaping teaspoonful of lye in one-half pint of clear water. Any household lye that consists of at least 94 percent of sodium hydroxide is suitable.

2. Pour the solution into a glass jar containing one-half pint of the sand. Cover the jar, and shake it vigorously for 1 or 2 minutes.

3. Let the contents settle for several hours. The color of the liquid will then indicate whether the sand contains harmful amounts of organic matter. A clear color indicates clean sand. A straw color indicates some organic matter, but not an objectionable amount. Darker colors indicate an excessive amount of organic matter in which case the sand is unsuitable and must be washed and retested before use.

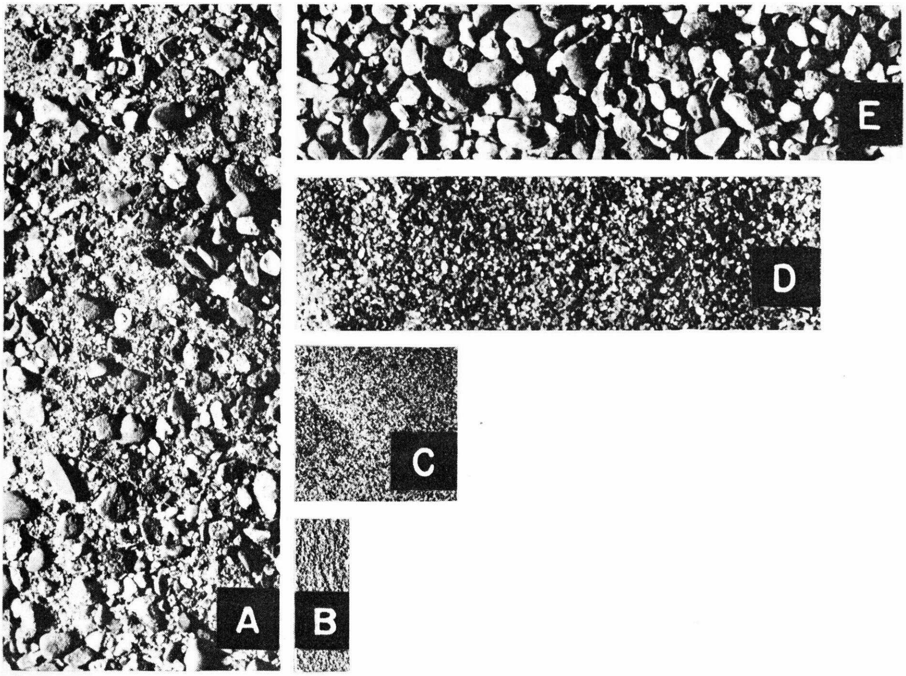

***Figure 1.*—Sample of well-graded sand: A, Before separation into various sizes; *B*, portion passing No. 100 screen; *C*, portion passing No. 48 screen but retained on No. 100; *D*, portion passing No. 14 screen but retained on No. 48; *E*, portion passing No. 4 screen but retained on No. 14.**

CAUTION: Measure the materials carefully in making this test, because variations in the concentration of the solution can alter the color. Avoid spilling the solution, because lye can cause severe personal injury and can damage clothing.

Lignite or coal deposits in the soil can give the liquid a very dark color. However, such impurities may not be present in sufficient quantity to reduce the strength of the concrete appreciably, and the sand may otherwise be acceptable. Laboratory tests should be made to determine their exact effect.

Coarse Aggregate

Gravel, crushed stone, and crushed slag are commonly used as coarse aggregate in farm concrete work.

Coarse aggregates should be sound, hard, and free of the same impurities that are objectionable in sand. A minimum of soft, flat, or elongated particles should be used.

The particles should range in size from 1/4 inch up to 1 1/2 or 2 inches (fig. 2). Nature of the work determines the maximum size to use. In general, the largest particles should not be more than one-fourth the thickness of the wall or slab.

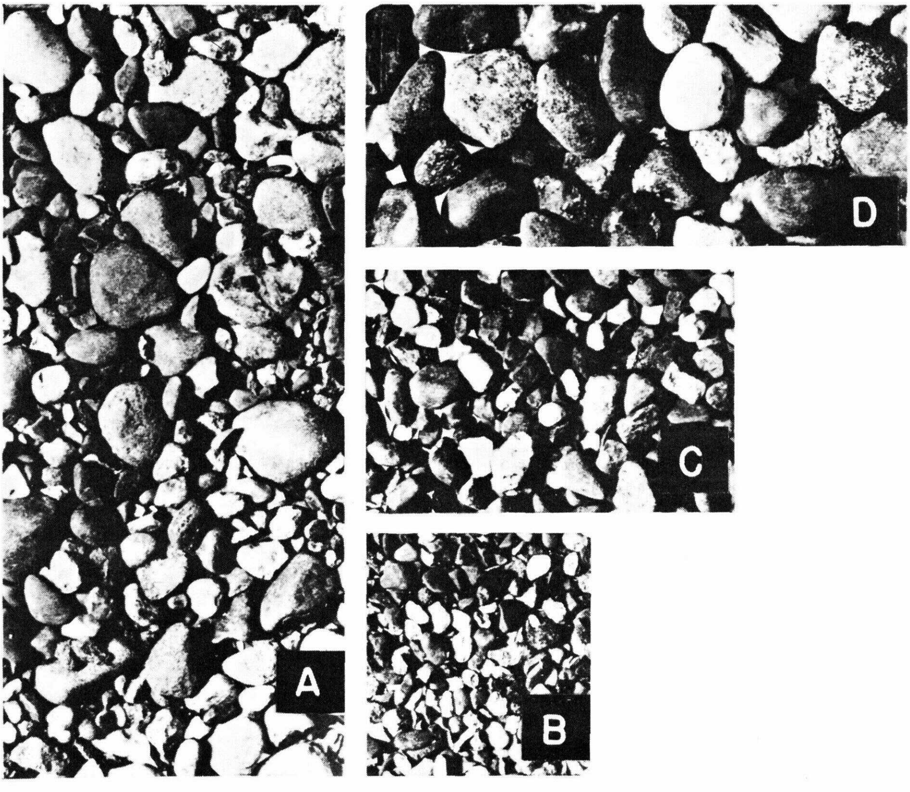

Figure 2.—Sample of well-graded gravel: *A*, Before separation into various sizes; *B*, portion passing 3/8-inch-mesh screen but retained on No. 4 screen; *C*, portion passing 3/4-inch-mesh screen but retained on 3/8-inch-mesh; *D*, portion passing 1 1/2-inch-mesh screen but retained on 3/4-inch-mesh.

You can greatly reduce the amount of concrete required for foundations and walls having a large cross section by using large stones (about the size of a man's head) as aggregate. The stones should be sound and clean and should be embedded at least 1 inch in the concrete so as not to show in the finished surface.

Bank Run Gravel

Bank or creek gravel that can fill the requirement for both sand and gravel can sometimes be obtained. It is frequently used in small concrete jobs just at it comes from the pit or creek.

Such material occasionally contains nearly the right proportion of sand and gravel required for good concrete, but usually there is an excess of either fine or coarse material. Most gravel banks contain an excess of sand in proportion to coarse material. More cement paste is required to produce concrete of a given quality when there is a high proportion of fine aggregate.

To determine whether bank run gravel contains the right proportion of sand and gravel, screen a representative sample of at least 2 cubic feet over a ¼-inch-mesh screen. Material that passes through is sand; that retained is gravel. The proportion should be comparable to that given in table 3, page 12, for the specific job.

If the proportion is not approximately correct, separate the sand and gravel by screening and remix them in the right proportion. The concrete will be stronger, and enough cement may be saved to pay for the cost of screening.

Some commercial firms sell a mixed aggregate. The sand and gravel are separated and then recombined into the correct proportion for concrete.

Lightweight Aggregates

Concrete ordinarily weighs about 150 pounds per cubic foot. Lighter weight concrete can be made by using lightweight aggregates that are available in many parts of the country. Lightweight aggregates also increase the fire-resistance and insulating qualities of the concrete.

Lightweight aggregates consist of cinders or expanded materials, such as clay, shale, or slag. They produce concrete weighing from 100 to 130 pounds per cubic foot. Concrete weighing as little as 50 pounds per cubic foot can be made with very lightweight aggregates, such as pumice or expanded mica.

Concrete made with lightweight aggregates is especially useful for filling between floor sleepers, for making precast blocks and roof slabs, and for fireproofing. It must not be used for watertight structures or where it will be subject to abrasion or heavy loads. When structural strength is required it should be used only by an experienced builder.

If cinders are used in making concrete, they should be composed of hard, clean, vitreous clinkers free from sulfides, soot, and unburned coal or ashes. Soak them in water for 24 hours before use to remove any detrimental substances. When clean, they will not discolor the hands when rubbed between them. Ashes from cookstoves and domestic heaters are not suitable aggregate. Lignite ashes contain alkali, which disintegrates concrete.

Lava rock varies widely in chemical composition and physical qualities. Some lavas are so light and frothy or contain so much easily oxidizable material that they are unsuitable for concrete work. Lava rock found in Washington and Oregon is usually satisfactory. Rhyolite, which is a light-colored volcanic rock, and many of the darker

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basaltic lavas are suitable for concrete for buildings.

Water

Mixing water for concrete should be clean and free of strong acid, oil, alkali, and organic matter.

Sea or brackish water should not be used because it may reduce the strength of the concrete. Alkali salts are destructive if in excess of 0.5 percent.

In general, water that is fit to drink is suitable for concrete.

Concrete Additives

Admixtures are sometimes put into concrete to improve workability, reduce segregation, entrain air, or accelerate setting and hardening. If improperly used, they can impair the quality of the concrete.

Fine materials, such as powdered pumice, fly ash, and hydrated lime, are sometimes added to improve workability. They usually reduce the strength of the concrete. Better ways to improve workability include: Add more cement to the mix, vary the mix proportions or the aggregate gradation, and place the cement at a slower rate.

Air-entraining agents must be added carefully—a small error in the amount added can make considerable difference in the amount of air in the concrete . Too much air is detrimental to the concrete. Follow the manufacturer's recommendation to obtain the desired air content.

Calcium chloride may be added to accelerate setting and hardening. Between 1 and 2 pounds per sack of cement may be added. Never add more than 2 pounds per sack of cement. The chemical may be added in solution in the mixing water or as crystals in the aggregate. It should not be mixed with the cement until the materials are put in the mixer.

Finely ground mineral oxides may be added to give concrete color. Three to 6 pounds per sack of cement should be enough to develop the desired tone. Longer mixing time will be necessary to obtain uniformity of color throughout the concrete.

Forms

Fresh concrete is heavy and plastic. Forms for holding it in place until it hardens must be well braced and should have a smooth inside surface. Cracks, knots, or other imperfections in the forms may be permanently reproduced in the concrete surface.

Wood is commonly used for forms, because of its light weight and strength. Since the cracks between boards can mar the concrete surface, plywood is often used. The special high-density overlay surface on plywood provides a smooth casting surface and facilitates removal of the forms for reuse.

If unsurfaced wood is used for forms, oil or grease the inside surface to facilitate removal of the forms and to prevent the wood from drawing too much water from the concrete. Do not oil or grease the wood if the concrete surface will be painted or stuccoed.

Forms for flat work, such as pavements, may be 2- by 4- or 2- by 6-inch lumber, the size depending on the thickness of the slab. Stakes spaced 4 feet on center hold the forms in place.

Figures 3 and 4 show forms for straight-wall construction. To prevent the forms from bulging, opposite studs should be tied together with 10- to 12-gage wire which should be twisted to draw the form walls tight against wooden spacer blocks. (The blocks are removed as the concrete is placed.)

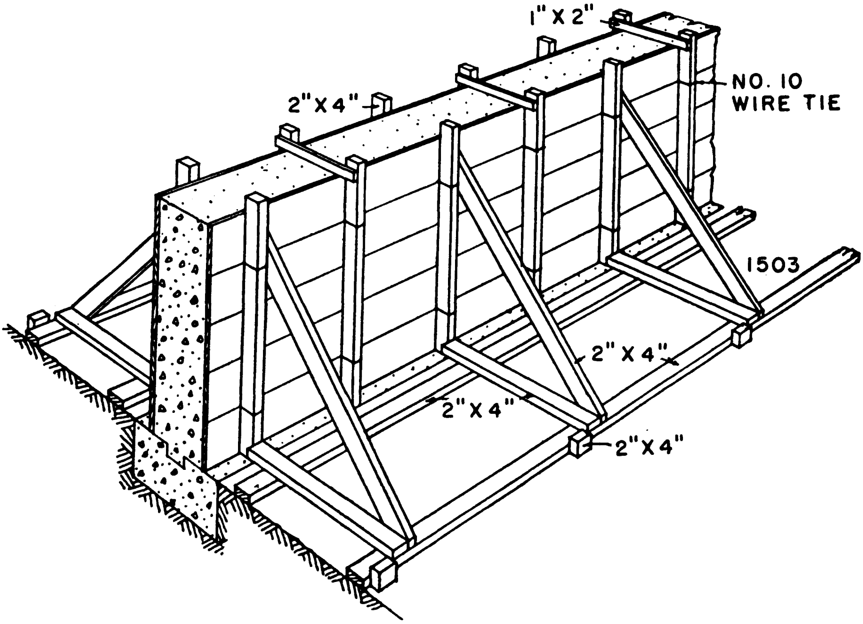

Figure 3.—**Forms for a straight wall on level ground.**

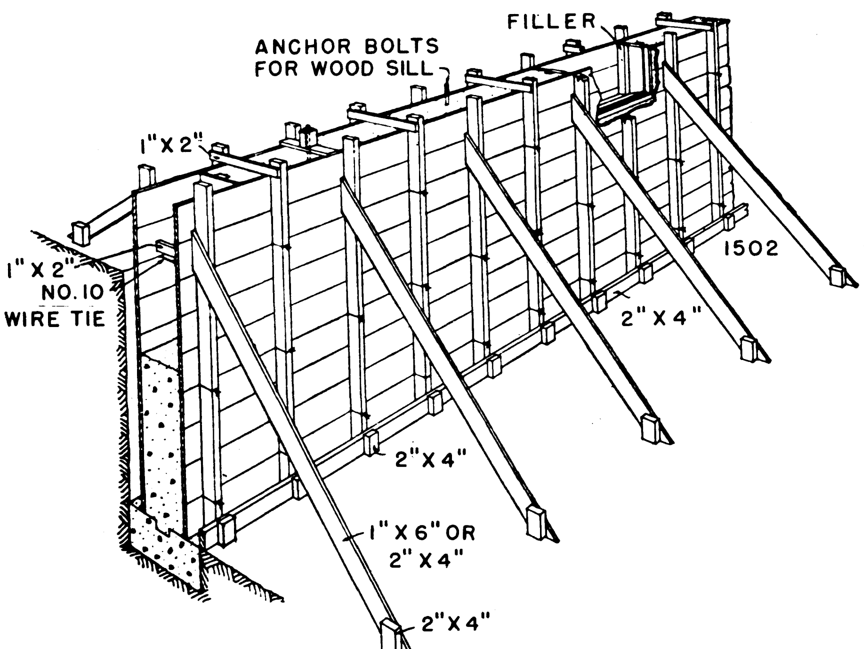

Figure 4.—**Forms for a basement or cellar wall. The earth can be used as the outside form if sufficiently firm.**

The ties should be spaced about 2½ feet vertically on the studs. When the forms are removed, clip the wires close to the concrete and punch them back. Pit holes caused by punching back the wires should be pointed up with mortar.

Forms made of other materials are sometimes used. For example, metal forming is more economical for repeated work, such as curbs, slip forming for monolithic concrete tanks or silos, and reinforced concrete floors for multistory buildings.

The finest natural finish on a concrete surface can be obtained by casting on polyethylene. Sometimes polyethylene forms are used for decorative work, or a kraft paper with a polyethylene film surface is used as form liner.

Use of forming materials that are left in place may be economical for reinforced floors, roof decks, and similar work. Such materials include steel, tile, and precast concrete unit masonry.

Mixing

Proportioning of Materials

Concrete mixes are designated by three numbers—for example, 1:2:3—indicating the proportion of cement, sand, and gravel (or other coarse aggregate) used. A 1:2:3 mix indicates 1 part cement, 2 parts sand, and 3 parts gravel. Different mixes are used for different kinds of concrete work.

Table 3 lists concrete mixes for various kinds of work. It also indicates the quantity of water required per bag of cement. The cement-sand-gravel proportion may have to be varied slightly to obtain a workable concrete mix, *but the water-cement ratio should never be changed.* The water-cement ratio determines the quality of the cement paste, which in turn determines the strength, durability, and watertightness of the concrete.

Note that the water-cement ratio varies according to the moisture content of the sand. Moisture con-

TABLE 3.—*Trial concrete mixtures for various kinds of work*

Kind of work	Proportions			Water required per sack of cement with sand—		
	Cement	Sand	Gravel	Wet	Moist	Dry
	Sacks	*Cubic feet*	*Cubic feet*	*Gallons*	*Gallons*	*Gallons*
Very thin work—2 to 4 inches thick (fence posts, milk cooling tanks)	1	2	2	3½	3¾	4½
Exceptionally watertight and abrasion-resistant work—4 to 8 inches thick (tanks, corner posts, silos)	1	2	3	3¾	4½	5½
General reinforced and watertight work—8 to 12 inches thick (basement walls, pavements, steps)	1	2½	3½	4½	5	6½
Mass concrete work of moderate strength and not watertight (footings, foundation walls)	1	3	5	5	6	7

tent of the sand may be determined by squeezing some in the hand. If the sand forms a firm ball, it is wet. If it forms a ball that tends to crumble, it is moist. If it falls free, it is dry.

Trial Mixing

The cement-sand-gravel proportions given in table 3 are trial proportions. It is not possible to give definite proportions, because of the variation in aggregates.

Mix a batch of concrete, using the appropriate trial proportion from the table and the correct water-cement ratio.

NOTE: The amounts of materials and the water-cement ratio are based on one-bag (of cement) batches. If a smaller batch is mixed, reduce the amounts of materials and the water-cement ratio proportionately.

Mix the concrete thoroughly. Then stop the mixer and examine the batch by reaching in and working the surface with a float. A workable mix should be smooth and plastic—not so wet that it will run or so stiff that it will crumble.

- If the mix is too wet, add small amounts of sand and gravel, in the proper proportion, until a workable mix is obtained.
- If the mix is too stiff, add small amounts of water and cement, maintaining the proper water-cement ratio, until a workable mix is obtained.

After each addition of sand and gravel, or of water and cement, run the mixer and reexamine the batch. Note the amounts of materials added so that subsequent batches can be properly proportioned initially. *Never add water to a mix without adding cement. Water will dilute and weaken the cement paste and thus reduce the strength of the concrete.*

In some cases, the mix may be too sandy or too stony. When this occurs, it is advisable to make a second trial batch and to vary the proportions of sand and gravel until the desired workability is obtained.

Concrete materials should be measured as accurately as possible:

Water can be measured in a pail marked off in gallons, half gallons, and lesser quantities.

One bag of portland cement contains 1 cubic foot of cement. Cement in quantities of less than one bag can be measured in a calibrated 1-cubic-foot box or pail.

To measure sand and gravel, count the shovelfuls required to fill a cubic foot box or pail. Measuring can then be done by shovelfuls into the mixer. This method is sufficiently accurate for most concrete work.

Estimating Materials Requirements

Table 4 shows the approximate amount of materials required to make 1 cubic yard of concrete of different mixes. To find the amount of materials required for a specific job—

1. Determine the cubic yardage of the space inside the forms. This gives the number of cubic yards of concrete needed.
2. Multiply the appropriate figures in table 4 by the number of cubic yards of concrete needed.

Example

You need 12 cubic yards of concrete of a 1:2:3 mix.

Table 4 shows that 7 bags of cement, 0.52 cubic yards of sand, and 0.78 cubic yards of gravel are required to make 1 cubic yard.

Therefore, you need:

$7 \times 12 = 84$ bags of cement.
$0.52 \times 12 = 6\frac{1}{4}$ cubic yards of sand.
$0.78 \times 12 = 9\frac{1}{2}$ cubic yards of gravel (approximate).

Order about 10 percent extra of each material to allow for waste or slight miscalculation in the amounts needed.

TABLE 4.—*Approximate quantities of materials required for making 1 cubic yard of concrete in place* [1]

Proportions of the concrete or mortar [2]			Quantities of materials		
Cement	Sand	Gravel or stone	Cement	Sand (damp and loose)	Gravel (loose)
			Sacks	*Cubic yards*	*Cubic yards*
1	1. 5	----	15. 5	0. 86	----
1	2. 0	----	12. 8	. 95	----
1	2. 5	----	11. 0	1. 02	----
1	3. 0	----	9. 6	1. 07	----
1	1. 5	3	7. 6	. 42	0. 85
1	2. 0	2	8. 2	. 60	. 60
1	2. 0	3	7. 0	. 52	. 78
1	2. 0	4	6. 0	. 44	. 89
1	2. 5	3. 5	5. 9	. 55	. 77
1	2. 5	4	5. 6	. 52	. 83
1	2. 5	5	5. 0	. 46	. 92
1	3. 0	5	4. 6	. 51	. 85
1	3. 0	6	4. 2	. 47	. 94

[1] The quantities of materials required may vary as much as 10 percent, the variation depending on the aggregate used.
[2] The first four proportions are for mortar mixes. Coarse aggregate is not used in making mortar.

Machine Mixing

Concrete should be thoroughly mixed. Thorough mixing increases the strength of the water-cement paste and improves the workability of the concrete. For machine mixing (fig. 5), allow 5 or 6 minutes mixing time after all materials are in the drum.

Place about 10 percent of the mixing water in the drum before adding the dry materials. Then add water uniformly with the dry materials, leaving 10 percent to be added after the dry materials are in the drum.

Placing

Place the concrete within 20 minutes after mixing is completed. In warm weather, initial set will occur in about 20 minutes, and if concrete is disturbed after initial set, it loses strength. Never rewet and remix concrete that has set before it can be placed in the forms—discard it.

Place concrete as near as practical to its final position in the forms. Honeycombing and segregation may occur if it is pushed or flowed for some distance into position. Spade the concrete as it goes into the forms.

If concrete is overworked in the form, the finer materials, including the cement paste, tend to work to the top, resulting in a nonhomogenous mixture of unequal density. Push a flat, spadelike tool down the walls of the form through the concrete to release air pockets against the wall (fig. 6). Lightly rod the concrete throughout to relieve entrapped air and insure intimate contact with the form.

Fresh concrete will not bond readily to hardened concrete, and the resultant seam may permit water to seep through. To bond new

concrete to concrete that has been in place a short time, roughen the surface of the hardened concrete with a pick to expose the gravel or stone. Clean off loose particles.

To provide a bond for the next day's work, roughen the surface of the concrete just before it hardens. Before placing the new concrete, soak the hardened concrete with water, remove the excess water, and apply a coat of grout.

If the pouring of a wall will be discontinued for some time, provide for bonding of future work by embedding short steel dowels in the concrete when it is poured or by cutting a rebate groove in the concrete (fig. 7, *C*).

To bond a new wall to an old one, drill holes for dowels in the old wall and grout the dowels in. Then roughen, clean, and wet the old surface.

Concreting in Cold and Hot Weather

Placing concrete in freezing or very cold weather is not recommended. The expense and trouble of heating the mixing water and aggregates before use and of protecting the finished work (which may include supplying heat with some type of heating equipment) to prevent freezing is not warranted for most farm concrete jobs.

Hot, dry weather also presents special problems. Curing must be started promptly to prevent too-rapid drying, which can reduce the strength of the concrete and cause cracking. In hot weather, it is advisable to place concrete late in the afternoon when the temperature has dropped.

***Figure 5.*—Concrete mixers are available in various capacities.**

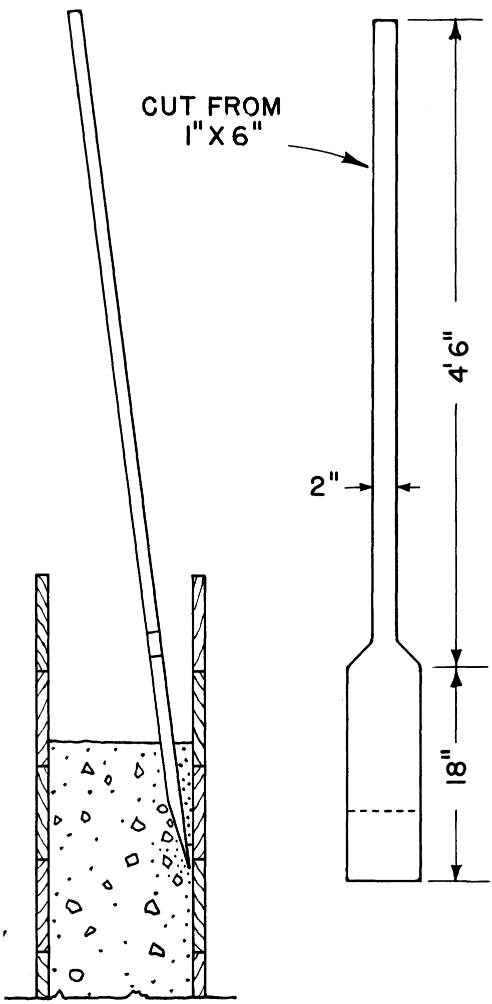

***Figure 6.*—Wooden spade for working concrete along the form.**

Joints

Concrete expands and contracts with changes in temperature. Joints must be provided to allow for the movement and thus prevent, reduce, or control cracking.

Concrete slabs (yard pavements, feeding floors, etc.) may be cast in 10- to 15-foot square or rectangular blocks. Two layers of 15-pound builders' felt may be placed between the blocks (fig. 7, *A*), or a ½-inch space may be left between blocks and later filled with asphalt.

Slabs may also be cast in 10- to 12-foot wide strips. Joints may be provided between strips as indicated above. Control joints—called "dummy" joints—should be cut at 10- to 15-foot intervals across each strip (fig. 7, *B*). The joints should be cut to one-fourth the thickness of the slab and may be cut with an ax or hoe and a straightedge. (Contractors often use concrete saws to cut control joints in concrete after it hardens. This method is satisfactory, but requires the proper tool and some experience.)

Where a slab abuts a wall, a ¾-inch joint should be provided be-

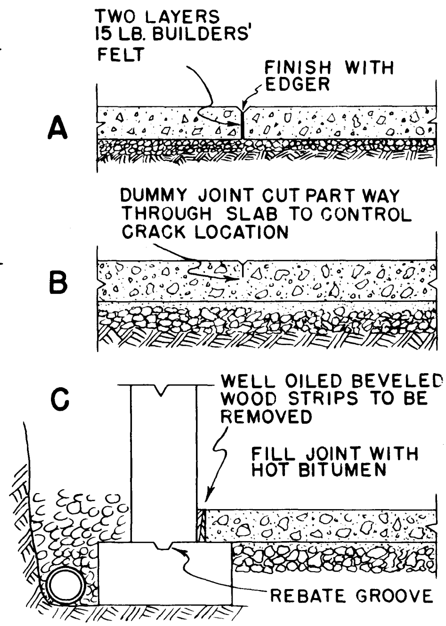

***Figure 7.*—Joints for concrete slabs: *A*, Joint between concrete blocks or strips in slab; *B*, "dummy" joint to control cracking; *C*, joint between slab and wall. Rebate grooves are used to bond sections of concrete.**

tween the slab and wall. Place two wedge-shaped boards along the wall (fig. 7, *C*). After the slab is cast, remove the boards and fill the joint with hot bitumen (asphalt).

Concrete floor slabs for houses are usually cast as one continuous unit. To control cracking, they should be reinforced with steel consisting of 10-gage welded wire with a mesh size of 6 by 6 inches. The reinforcement will not prevent cracks, but will prevent them from enlarging. A general rule of thumb is to provide a steel area of 0.3 percent of the cross section area of the concrete. This applies when casting ordinary slabs not more than 45 to 50 feet in length.

Finishing

Flat Work

After the concrete is placed, it is screeded, or leveled off in the forms, with a straightedge (fig. 8). Then it is floated with a long-handled float—called a bull float—to obtain a more even finish. Final surface finishing is delayed until the concrete has become stiff and the water sheen has disappeared.

The three general textures of final surface finish are the rough broom, the wood float, and the steel trowel.

- The rough-broom finish provides a slip-proof surface and should be used on yards, floors, and other surfaces where livestock walk.
- The wood-float finish provides an even, gritty surface and is used on general work, such as farm-building floors and sidewalks.
- The steel-trowel finish provides a smooth, dense surface and is used on milkhouse floors and other work requiring a highly finished surface.

Walls

Walls may be finished by removing the forms while the concrete is still partially set, rubbing off irregularities with a brick, pointing up voids with mortar or neat cement (a mix containing no sand), and brushing the surface with a coat of water and cement mixed to the consistency of heavy cream.

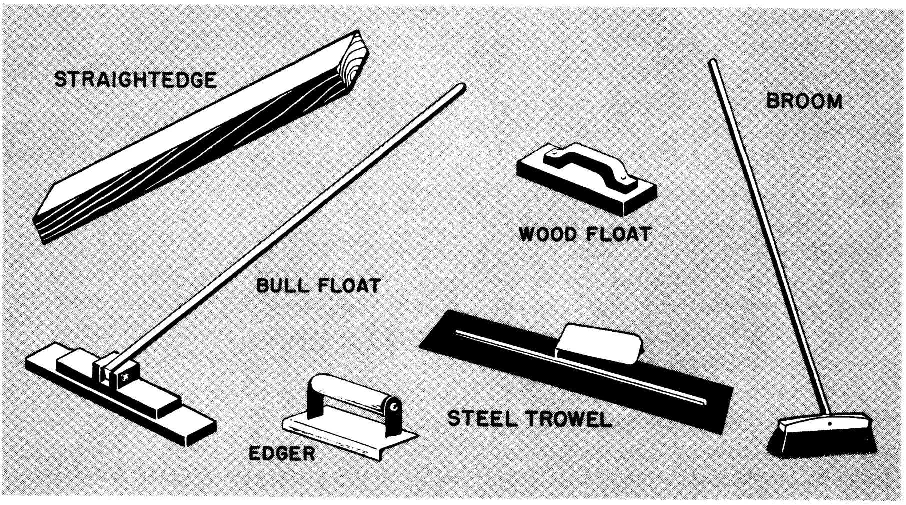

***Figure 8.*—Some tools for finishing concrete surfaces.**

Special Treatments

Patios, porch floors, and similar work will be more attractive and easier to clean if the surface is clay tiled.

For a dense, dust-free floor in milking parlors and similar places, concrete paint should be considered.

Special concrete paints containing abrasion-resistant pigment are available. Follow the manufacturer's direction when using them. Before painting a floor, clean it thoroughly. To neutralize alkalinity, brush the surface with solution of 4 pounds of zinc sulfate and 1 gallon of water. After 48 hours, when the surface is dry, apply the paint.

Milkhouse floors may be treated in several ways to protect them against the lactic acid in milk products:

First method.—Apply two coats of boiled linseed oil. The oil will penetrate better if diluted. Use one-half oil and one-half mineral spirits, naphtha, turpentine, or similar volatile thinner. Work the oil around with a brush or mop. Remove the excess oil before the oil becomes tacky. After this treatment, apply a hard floor wax. The wax should be renewed from time to time.

Second method.—Spread on the floor a paste compound of 4 parts paraffin, 1 part turpentine, and 16 parts toluol (by weight). *This mixture is highly flammable—handle it with extreme care.* Let the mixture penetrate for 24 hours. Then drive it into the concrete with heat. Use a hot iron, because an open flame can create a fire hazard. Apply a hard floor wax. Renew the wax from time to time.

White portland cement mixed with water and applied with a stiff-bristled brush makes a good finish for concrete walls. If the walls need a gloss finish, a concrete paint may be applied. More permanent walls of glazed tile may be preferable in milking rooms and similar places.

Curing

Proper curing is essential for good concrete. And thin work requires more care in curing than massive work.

If concrete dries out too fast, it may not attain adequate strength and excessive shrinkage and cracking may occur. It must be kept moist for at least 4 or 5 days.

Flat Work

Slabs and other flat work can be cured by several methods:

- Cover the concrete with burlap, straw, or similar material, and keep the material wet.
- Cover the concrete with a watertight cover to seal in the water and prevent evaporation.
- Flood or pond the surface, retaining the water by means of an earth dike around the slab.
- Spray a commercial curing compound on the surface to seal it.

Polyethylene is one of the most effective watertight covers. As soon as possible after final finishing of the surface, wet it and cover it with a polyethylene sheet. If the sun beats down on the job, throw some straw on top of the polyethylene to reflect some of the heat.

Walls

Walls may be cured by leaving the forms in place and keeping them wet. If it is necessary to remove the forms, cover the concrete surface with canvas or burlap, and keep that material wet.

Precast Units

Cracking may be prevented in small precast units, such as fence posts, by prestressing the reinforcing steel. The steel is released after the concrete has cured from 30 to 60 hours, but while it is still "green." This method requires careful judgment as to the elasticity of the steel and the time to release the steel, and several trials may be necessary before it can be done successfully. Prestressing the steel reinforcement helps to achieve a good cure without cracks. However, it should not be used in place of curing by moisture retention, but in conjunction with that method.

Watertight Concrete

First-class workmanship is essential for watertight concrete. Other important requirements are:

- Use a fairly rich mixture with a low water-cement ratio. Mix the concrete to a sluggishly flowing consistency. Maintain the same proportion of materials and the same mix consistency for each batch of the concrete.
- Reinforce the concrete.
- Place the concrete in one continuous operation. If that is not possible, provide watertight joints between hardened concrete and new concrete.
- Provide contraction and expansion joints.
- Cure the concrete properly.

Additional measures may be taken to insure dry basement or cellar walls. These are:

1. Grade the ground around the building to provide surface drainage away from the walls.
2. Install drain tile around the outside of the footings.
3. Apply a ½-inch-thick coat of portland cement and two coats of hot coal tar pitch to the outside of the walls.

CONCRETE FARM STRUCTURES

Pavements

Feeding floors, feedlots, and other pavements should be cast on firm ground that has been cleared of organic matter and graded to the proper slope.

Gravel, crushed rock, or other granular material may be used as a subbase or to fill in low places.

A 4-inch slab is sufficient for livestock. Increase the thickness to 6 inches if machinery will be driven over the pavement. For good drainage, a pavement should slope at least one-fourth inch per foot.

The recommended method of casting pavements is in 10- to 15-foot square or rectangular blocks (fig. 9). Cast the pavement in alternate strips and in alternate blocks within each strip. Provide expansion joints between the blocks (fig. 7, *A*).

Pavements may also be cast in 10- to 12-foot wide strips. The strips should be cast alternately. Provide expansion joints between strips and control (dummy) joints across each strip (fig. 7, *B*).

A thickened edge 18 inches wide along the perimeter of the slab will prevent trucks or other equipment from breaking and crumbling the edge (fig. 10). If the slab rests on soil subject to high change in moisture content, tie the edge to the slab with reinforcing steel, because

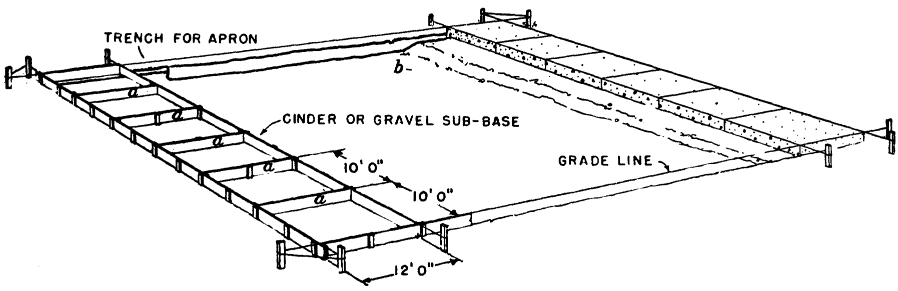

Figure 9.—Forms for casting concrete slabs in blocks.

the soil will move up and down more along the edge than it will in the center of the slab (fig. 10).

Rough concrete pavements can be mixed in place. This method leaves more chance for poor workmanship than using ready-mix concrete or mixing the concrete in a mixer, but it involves less labor and provides a satisfactory feedlot.

NOTE: Mixing concrete in place should not be confused with mixing portland cement in soil. In the latter method, the cement is disked into the soil, and then the earth is dampened and packed. (This mixture of concrete and soil is called stabilized earth.) This method is not recommended for pavements, because clean, organic-free aggregates are essential for good concrete.

To construct a mixed-in-place concrete feeding floor:

1. Clear the site of organic surface material.
2. Spread on the site a 7-inch layer of good bank-run gravel or the equivalent in sand and gravel. Level the surface.
3. Spread one bag of portland cement on each 4- by 4-foot section (16 square feet) of the surface.
4. Using a spring-tooth or disk harrow, thoroughly mix the cement and aggregate to a depth of 6 inches.
5. Moisten the mixture to a consistency where it makes a firm ball when squeezed in the hand. Do not moisten more surface than can be thoroughly packed within a period of 20 minutes.
6. Compact the concrete with a heavy tractor wheel, pneumatic tamper, or road roller.
7. Follow good curing practices.

Walks

Concrete walks may be 1½ feet wide or more. Figure 11 shows the usual method of setting up the forms. Expansion joints are usually provided at 4- or 5-foot intervals.

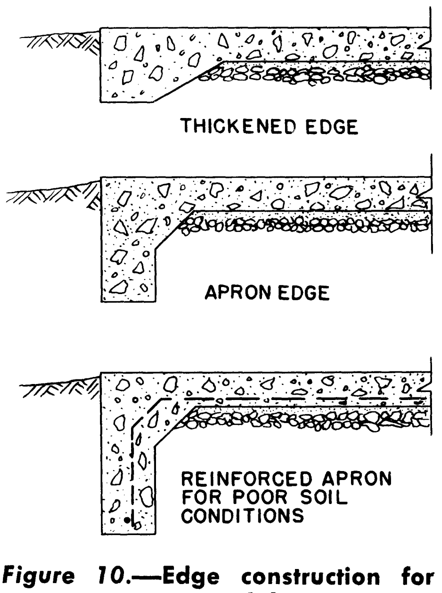

Figure 10.—Edge construction for concrete slabs.

To prevent water from standing on the surface, the walk may be built a little higher than the surrounding ground and crowned, or it may be built with one side slightly higher than the other. Water from downspouts should be diverted so that it will not flow across the walk and become an ice hazard in winter.

Ordinarily, a 4-inch slab of one-course construction will be sufficient. But if heavy vehicles will be driven over the walk, it should be 6 inches thick.

A broomed or float finish is desirable for level or slightly inclined walks. For steeper grades, a coarse, scored surface is advisable. This is made by running a stiff broom crosswise to the direction of travel.

Steps

Concrete steps are built by casting the risers (vertical part) and treads (horizontal part) on an inclined slab, the thickness of which depends on the span or method of support.

When the slab rests on solid earth or on earth fill and there are only three or four steps from 3 to 4 feet wide, a 4-inch slab is sufficient. For wider and longer flights, however, the slab should be 6 inches or more in thickness. Figure 12 shows two arrangements of forms for earth-supported steps.

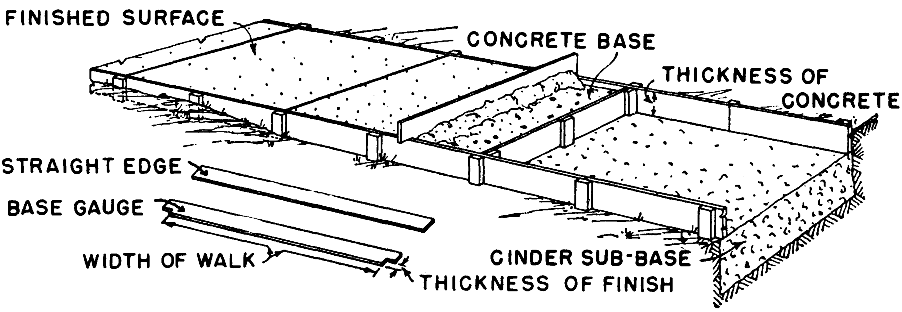

Figure 11.—**Forms for sidewalks.**

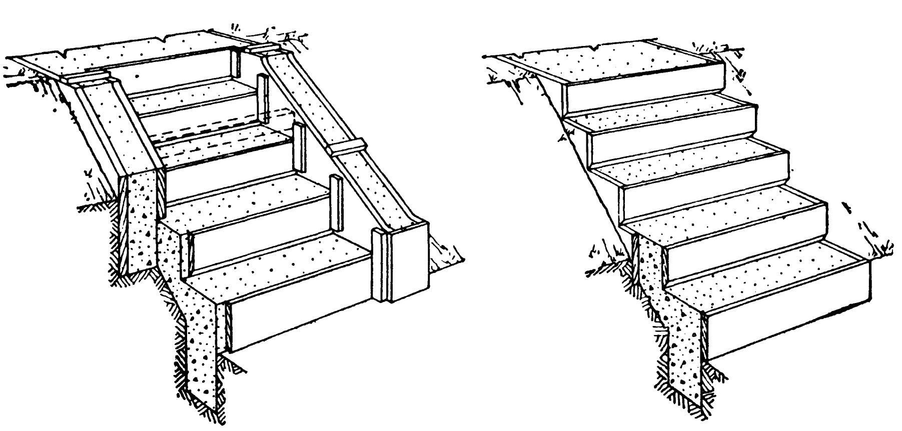

Figure 12.—**Forms for earth-supported steps. Parts of forms are cut away to show construction.**

Steps that do not rest on solid earth or on earth fill must be self-supporting and, therefore, reinforced (fig. 13). Table 5 gives the reinforcement required for slabs of different lengths and thicknesses. The longitudinal rods are placed lengthwise, from top to bottom, 1 inch up from the underside of the slab. The transverse rods are placed in the opposite direction and should extend across the width of the slab. Wire the longitudinal and transverse rods together where they intersect. Self-supporting steps must be firmly supported at the head, such as by a concrete porch or a masonry wall. The foot can be secured as shown in figure 13.

Low risers and wide treads are preferable for outdoor steps. Probably the safest and easiest steps to climb have risers 6 to 8 inches high and treads 10 to 11 inches wide. A good formula is: "Twice the height of the riser plus the width of the tread equals 25."

To provide more toe space and, therefore, easier and safer climbing, the treads may be projected three-quarters of an inch beyond the risers.

Treads should slope about one-sixteenth of an inch toward the front in order to shed water.

Porch Floors

Porch floors may be laid on an earth fill or supported above the ground.

When a porch is laid on earth fill, the earth must be well settled, a porous subbase (gravel or crushed rock) should be provided, and an apron (fig. 10) should be built under the edges of the slab. The slab should slope about one-fourth inch per foot to drain off water. NOTE: If the slab rests on earth fill more than 12 inches thick, it should be supported as indicated below.

Porches built above the ground may be supported by two walls built of 8-inch concrete block. Figure 14 shows construction details, and table 6 gives the slab thickness and reinforcement required for porches 4 to 10 feet wide. (Porches can be supported by reinforced girders resting on concrete piers, but the "wall" method is cheaper and easier when adding small porches to existing buildings.)

TABLE 5.—*Diameter and spacing of round rods required for reinforcing concrete step slabs*

Slab dimensions		Longitudinal rods		Transverse rods	
Length (feet)	Thickness (inches)	Diameter	Spacing	Diameter	Spacing
		Inches	*Inches*	*Inches*	*Inches*
2 to 3	4	1/4	10	1/4	12 to 18
3 to 4	4	1/4	5 1/2	1/4	12 to 18
4 to 5	5	1/4	4 1/2	1/4	18 to 24
5 to 6	5	3/8	7	1/4	18 to 24
6 to 7	6	3/8	6	1/4	18 to 24
7 to 8	6	3/8	4	1/4	18 to 24
8 to 9	7	1/2	7	1/4	18 to 24

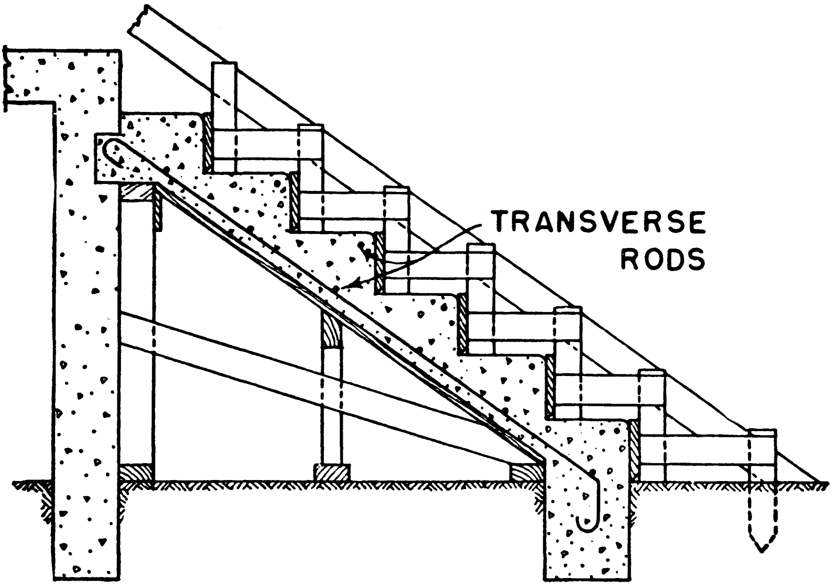

***Figure 13.*—Forms for self-supporting steps.**

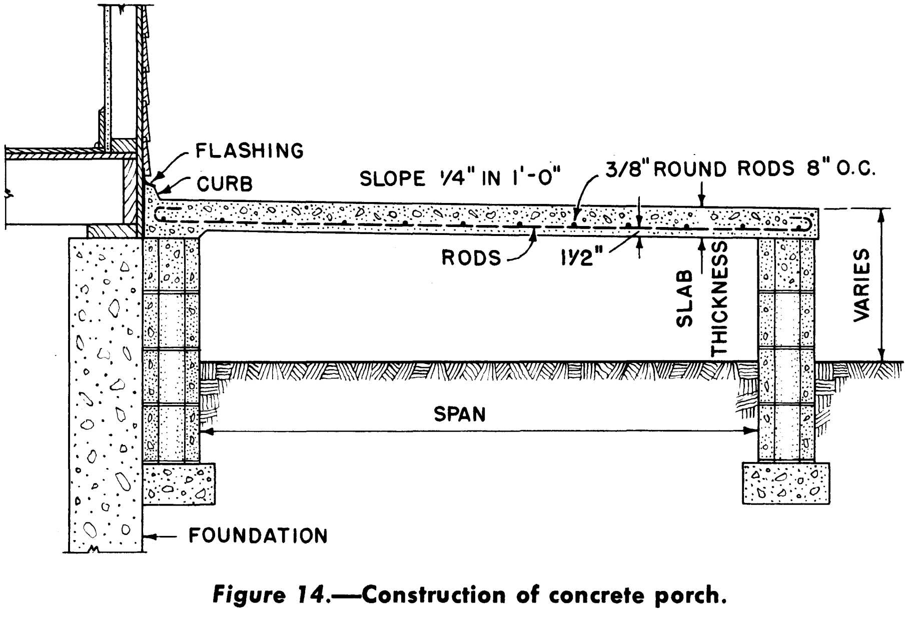

***Figure 14.*—Construction of concrete porch.**

TABLE 6.—*Thickness of slab and diameter and spacing of rod reinforcement required for supported concrete porches* [1]

Width of porch (feet)	Slab thickness	Reinforcing rods	
		Diameter	Spacing
	Inches	*Inches*	*Inches*
4	5	3/8	7½
6	5	3/8	6
8	5½	½	9½
10	6	½	8

[1] The transverse reinforcing rods are 3/8-inch round rods spaced 8 inches on center.

Tanks and Troughs

In many areas, precast concrete feed and water troughs are available from local concrete-products plants. It may be more economical to buy a precast trough than to build a trough.

A small, round stock-watering tank can be easily built with a section of concrete culvert pipe, as shown in figure 15.[1]

[1] Working drawings of this tank may be obtained through your county agent or from the Extension agricultural engineer at most State agricultural colleges. Give the *plan number* indicated in the illustration legend when you order. There is usually a small charge.

If working drawings are not available in your State, write to the U.S. Department of Agriculture, Agricultural Engineering Research Division, Plant Industry Station, Beltsville, Md., 20705. The Department of Agriculture does not distribute drawings, but will direct you to a State that does distribute them.

If you cast a trough, you can save forming by using tilt-up construction for the sidewalls (see "Tilt-Up Concrete Panels," p. 28). Reinforce the walls with No. 3 bars. Bend the bars (L-shaped) to provide reinforcement for the trough bottom, which is cast after the walls are in place.

Walls of fence-line feed troughs may be made of cast-in-place concrete or of concrete masonry units. Figure 16 shows construction with masonry units. The walls are anchored to the floor with No. 3 bars, spaced 2 feet on center and projected up through the core space in the masonry units. The core space is filled with mortar. A concrete cap, reinforced with one No. 3 bar, should be placed over the masonry units.

Feed troughs and gutters in stanchion-type dairy barns should be designed to fit the equipment used. The gutter for a barn cleaner should be about 16 inches wide and 10 to 14 inches deep (fig. 17, *B*).

Figure 17, *A* shows construction of a sweep-in-type dairy manger.

***Figure 15*.—Concrete watering tank. (Plan No. 5909.)**

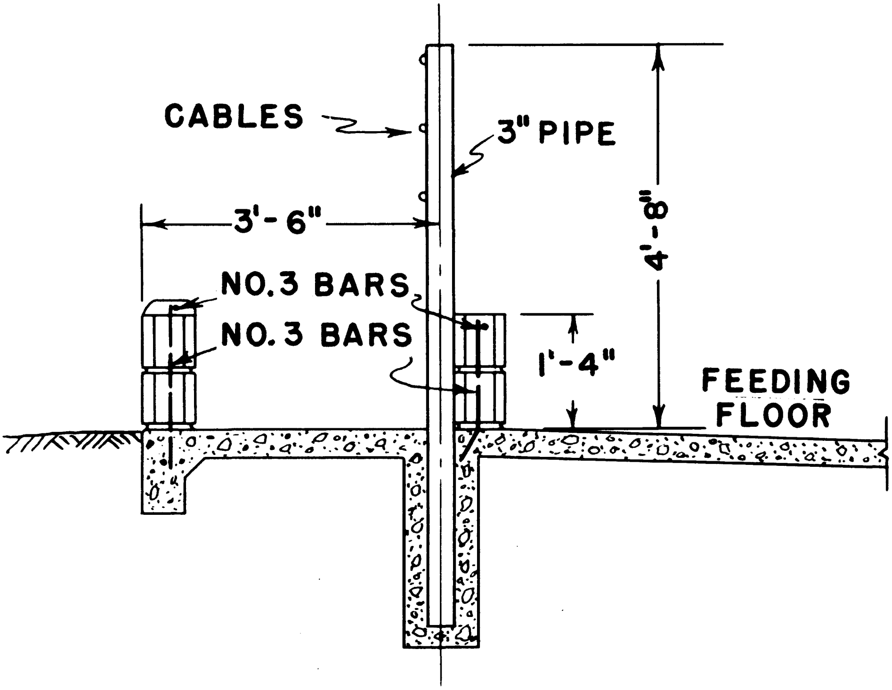

Figure 16.—Construction of feed trough with concrete masonry units.

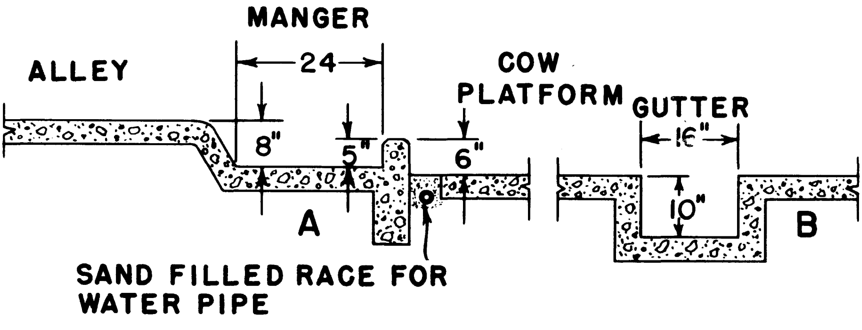

Figure 17.—Concrete sweep-in-type dairy manger and concrete gutter.

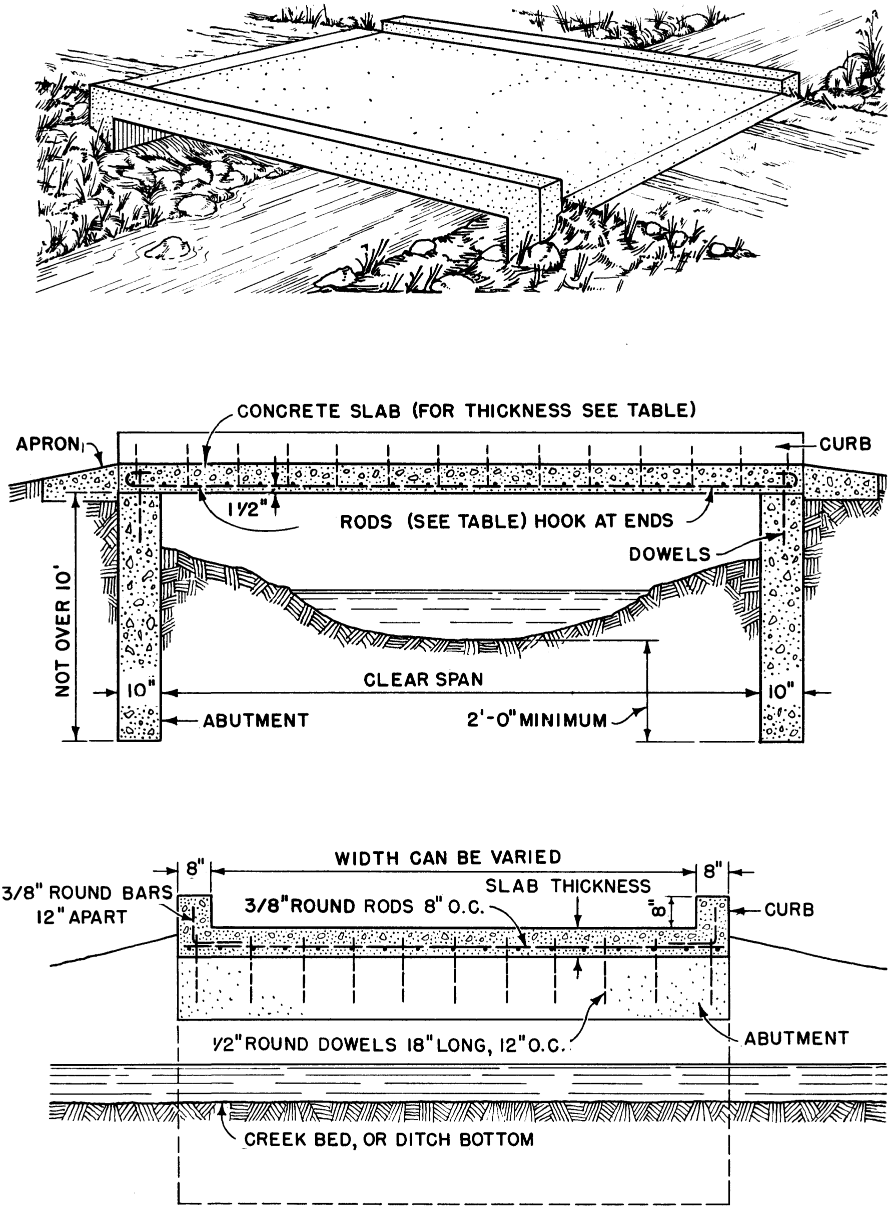

***Figure 18.*—Construction of concrete bridge.**

Bridges

Figure 18 shows construction of a bridge that will carry a 6-ton load. Table 7 gives the slab thickness and reinforcement required for four different spans. If the span is more than 15 feet or if the bridge must take heavier loads or cross a stream subject to washouts, an engineer should be consulted.

The best time to build bridges is during dry weather when the water level in the stream or irrigation ditch is low.

Plants that manufacture concrete products may sell culvert pipe that can be used to bridge ditches. The pipe may cost less to install than bridge.

TABLE 7.—*Thickness of slab and diameter and spacing of rod reinforcement required for small concrete bridges* [1]

Bridge span (feet)	Slab thickness	Reinforcing rods	
		Diameter	Spacing
	Inches	*Inches*	*Inches*
6	6½	⅝	8
9	6½	⅝	7
12	7	¾	8
15	8	¾	7

[1] The transverse reinforcing rods are ⅜-inch round rods spaced 8 inches on center.

Retaining Walls

Two types of retaining walls are commonly built—gravity and reinforced cantilever.

Figure 19 shows construction of a gravity-type wall. The footing should be below frost depth. Proper width for the footing depends on the height of the wall, as follows:

Wall height (feet)	Width of footing (feet)
3	2½
4	3
6	4
8	5½

Clean, sound field stones no larger than one-half the thickness of the wall may be used to reduce the amount of concrete needed.

Backfill should not be placed until the concrete has thoroughly hardened—usually after 27 days.

The weep holes, which drain water from back of the wall, consist of agricultural tile spaced 6 to 8 feet apart. They should drain 6 inches above the lower grade.

For retaining walls higher than 8 feet, the reinforced cantilever type may be less expensive (fig. 20). It should be designed by an engineer

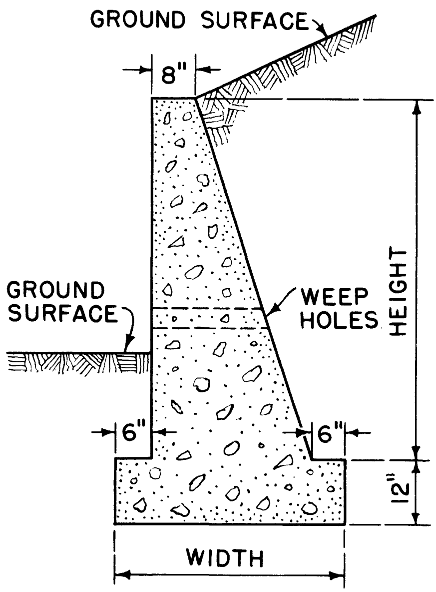

Figure 19.—Gravity-type retaining wall.

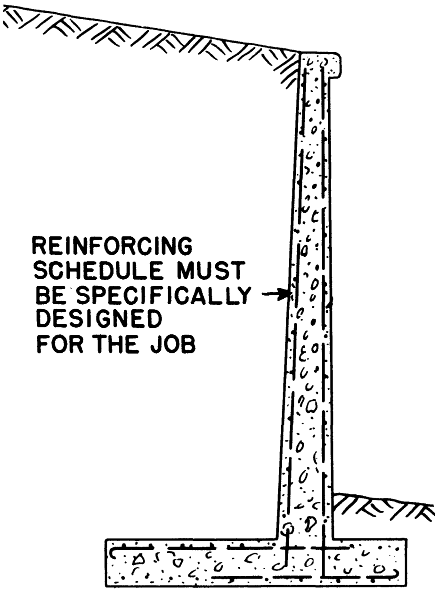

***Figure* 20.—Cantilever-type retaining wall.**

Tilt-Up Concrete Panels

Building walls may be made from precast concrete panels that are tilted into position.

Panels 3⅝ inches thick are cast on the concrete floor of the building or on a well-leveled sand bed in forms as shown in figure 21. The reinforcing bars should be 1 inch from the bottom of the panel.

The panels are tilted into position by means of a lifting frame and tractor (fig. 22). They are braced in position, and then reinforced columns are cast between the panels to tie them together (fig. 23).

Piers to support the panels should extend down to solid footing below the frost line.

Table 8 gives the pier requirements for walls made of 8- by 10- and 10- by 10-foot panels.

Fallout Shelter

Figure 24 shows a fallout shelter that provides excellent radiation protection. It can serve as a fruit and vegetable storage with potential use as an emergency shelter.

To obtain detailed information and plans for constructing the shelter, see footnote 1, page 24.

TABLE 8.—*Spacing, dimensions, and reinforcement of concrete piers for tilt-up concrete wall panels*

Panel dimensions (feet)	Piers		
	Spacing	Dimensions [1]	Vertical reinforcement
	Feet	*Inches*	
8 by 8	8	12 by 24	3 No. 4 bars.
10 by 10	10	12 by 32	3 No. 6 bars.

[1] Soil-bearing capacity assumed to be 4,000 pounds per square foot. For clear-span roof construction, increase either dimension of piers by 50 percent.

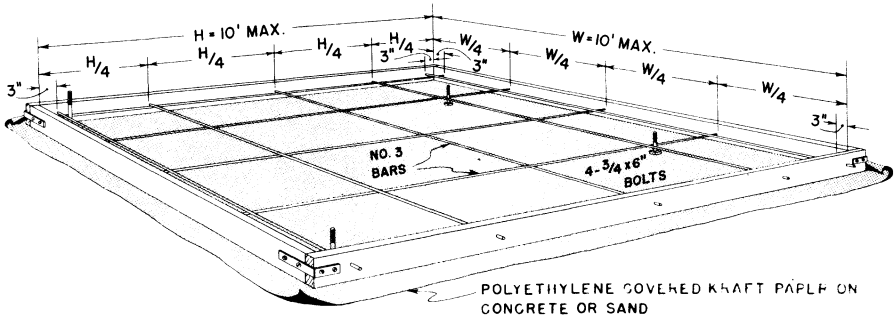

***Figure 21*.—Forms for tilt-up concrete panels.**

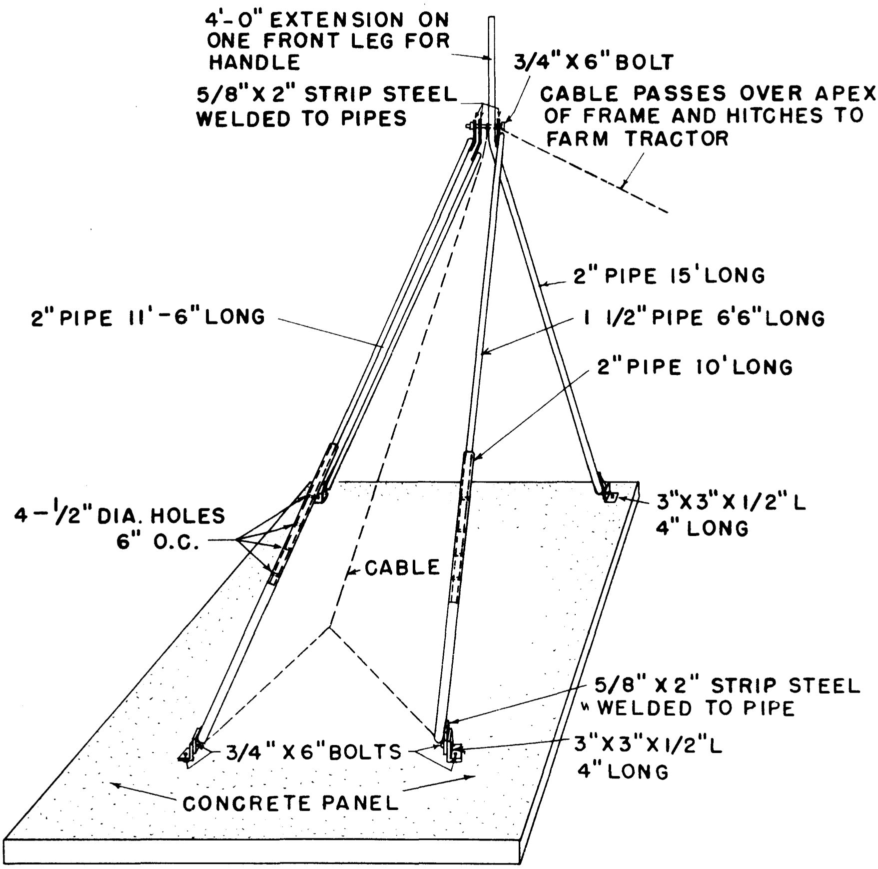

***Figure 22*.—Lifting frame for tilt-up concrete panels.**

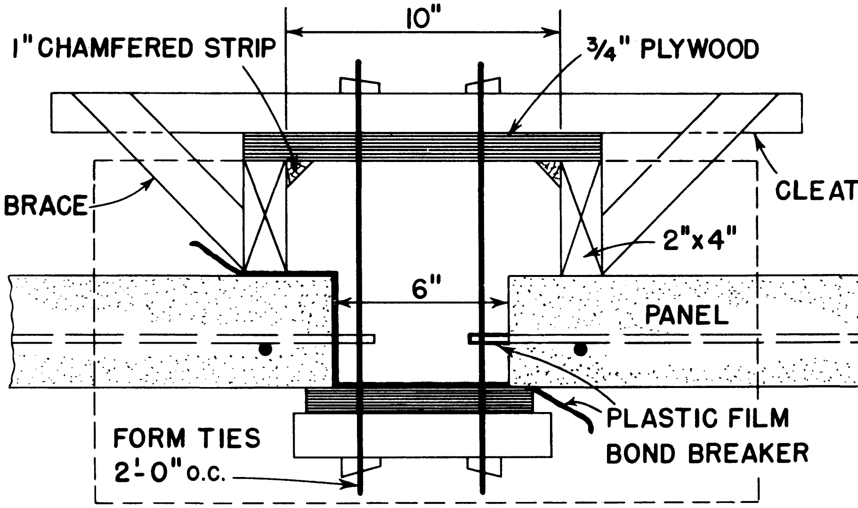

Figure 23.—**Forms for concrete columns between tilt-up concrete panels.**

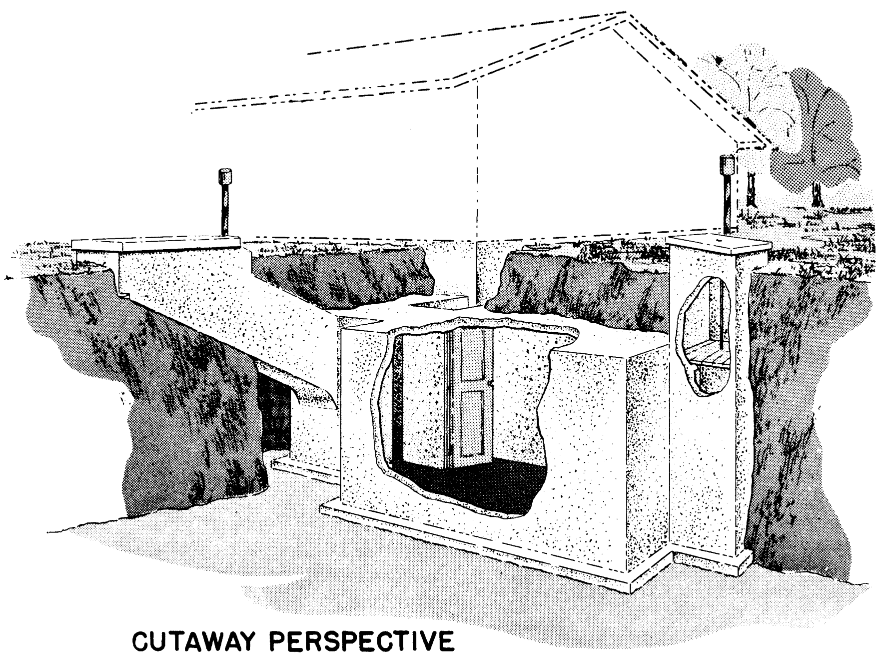

Figure 24.—**Fallout shelter and storage. (Plan No. 5934.)**

REPAIR OF CONCRETE

Basement Walls

Leaky basement walls cause trouble and repair can be expensive. You can avoid them by careful construction. Three basic preventive measures are:

1. Install drain tile around the footing.

2. Place a continuous waterproof coating on the outside of the basement walls.

3. Grade the ground around the building so as to provide good water drainage away from the walls.

Existing walls may develop leaks because of poor initial construction or because soil movement causes cracks in the wall. Minor leakage can sometimes be checked by inside repair work, but the work usually has to be repeated. Cracks are chiseled out—preferably in an inverted **V**-shape—and filled with a hydraulic cement. Then the walls are given one or two coats of a waterproofing masonry paint.

Inside repair work seldom controls major leakage for long. It may be necessary to excavate around the outside of the foundation, install drain tile, parge the walls (plaster with portland cement mortar), and cover the walls with a waterproof membrane.

Floors

Concrete floor repair generally consists of resurfacing or patching holes or worn spots. Inside work that will not be subject to freezing and thawing can be thinner in depth than outside work. Bonding agents that contain latex or modified epoxies may suffice for thin resurfacing work, but they are more expensive than ordinary concrete.

When patching holes or regrading shallow sinks, trim the old concrete away until sound material is reached, or at least deep enough to allow for 1 inch of new material. Edges of adjacent good concrete should be kept nearly vertical. Soak the old concrete with water, remove the excess water, and apply a coat of grout. While the surface is still moist, place and ram the new concrete. Let the new concrete stand for 5 to 20 minutes, and then ram it again. Work the surface with a wood float to make it conform with the surrounding concrete. Keep the new concrete covered and moist for several days.

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CHECK up on these accident hazards around your farm . . .

√ Is farmyard clear of tools, broken glass, loose strands of barbed wire, nail-studded boards?

√ Are water tanks, cisterns, and wells protected?

√ Are ladders and steps in good repair?

√ Are pitchforks, rakes, shovels, and other sharp tools kept in racks?

√ Are electric circuits and appliances in good condition?

√ Is unused lumber carefully stacked?

√ Are buildings and fences in good repair?

clean up your farm

to make it attractive and SAFE